LONG-TERM ASSESSMENT ON THE GROWTH AND YIELD OF 15-YEAR-OLD PLANTATION-GROWN TEAK (TECTONA GRANDIS)

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INTRODUCTION

i. No natural teak stand in Malaysia but introduced in 1950s, widely planted as plantation species in various parts of Peninsular Malaysia especially in the northern states bordering South Thailand (Hashim & Mohd Noor 2002).

ii. Later planted in eastern and northern parts of Sabah, East Malaysia (Mohd Fauzi 2004)

iii. Financial incentives to private agencies and small holders (USD 3000 / ha, payable after 15 years) MTIB 2006

iv. Government initiatives to sustain the wood industry
Status quo of teak stands

• Almost negligible in terms of global hectarage (app. 2000-2500 ha estb. 1990s)
• No takers or active plantation despite the incentives
• Failures > success stories
• Land competition with agricultural crops
TALK OUTLINE

To present a case study:

i. the achieved stand growth and yield of plantation-grown teak in selected areas in Malaysia by comparing on the field performance in two different sites

ii. CL1 silty clay soil, with firm subsoil and distinct variegation at depth moderately well drained to imperfectly drained

iii. CL2 well structured, free draining, deep profile derived from a parent material of highly weathered granite, sandy clay texture, coarse with angular quartz grain, well drained and the permeability is good.

iv. Lastly to compare the growth and yield on extreme soil types
Study sites (Malaysia, Sabah, Tawau)
Study sites
General view of the sites

High diameter variation
Distinct clear bole length
Total height relates well with the sites quality
Study Approach (Measurements and Calculations)

- Two sites (CL1 & CL2) 3 km apart
- Area 13.30 ; A 6.91 ha; B 6.39 ha
- Additional site in P. Malaysia
- 100 % enumeration both DBH, $d_{\text{top}}$, total height and height to
- Dbh using *Haglof Clinometer* & Vertex Haglof digital hypsometer
- Tree volume using SMALIAN formula (average of dbh, dbh top, bole height)
- Sorted in accordance with descending order
## Overall Results / ha basis

<table>
<thead>
<tr>
<th>Site</th>
<th>DBH max</th>
<th>DBH min</th>
<th>N</th>
<th>Mean</th>
<th>Hg max</th>
<th>Mht max</th>
<th>Vol m</th>
<th>Vol t</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL 1</td>
<td>41.3</td>
<td>4.5</td>
<td>3,571</td>
<td>17.2</td>
<td>24.2</td>
<td>18.7</td>
<td>546.69</td>
<td>998.57</td>
</tr>
<tr>
<td>CL 2</td>
<td>58.7</td>
<td>8.0</td>
<td>3,816</td>
<td>18.8</td>
<td>30.6</td>
<td>20.0</td>
<td>731.63</td>
<td>1,316.74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>N</th>
<th>50 b</th>
<th>100 ddom</th>
<th>dbh</th>
<th>hg</th>
<th>Mvol</th>
<th>Tvol</th>
<th>MAIV/yr</th>
<th>Vol dom</th>
<th>Vdom/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL1</td>
<td>517</td>
<td>26.4</td>
<td>24.2</td>
<td>17.2</td>
<td>24.2</td>
<td>79.11</td>
<td>144.51</td>
<td>9.63</td>
<td>348.52</td>
<td>23.23</td>
</tr>
<tr>
<td>CL2</td>
<td>597</td>
<td>30.9</td>
<td>28.0</td>
<td>18.8</td>
<td>30.6</td>
<td>114.49</td>
<td>206.06</td>
<td>13.74</td>
<td>430.58</td>
<td>28.71</td>
</tr>
</tbody>
</table>
## Breakdown and percentage

<table>
<thead>
<tr>
<th>Dia.class (cm)</th>
<th>CL1</th>
<th>%</th>
<th>CL2</th>
<th>%</th>
<th>MAIdbh</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 above (max 58.7)</td>
<td>2</td>
<td>0.06</td>
<td>13</td>
<td>0.34</td>
<td>2.7</td>
</tr>
<tr>
<td>30-39.9</td>
<td>32</td>
<td>0.90</td>
<td>126</td>
<td>3.30</td>
<td>2.0-2.7</td>
</tr>
<tr>
<td>20-29.9</td>
<td>776</td>
<td>21.73</td>
<td>1156</td>
<td>30.30</td>
<td>1.3-1.9</td>
</tr>
<tr>
<td>10-19.9</td>
<td>2,741</td>
<td>76.76</td>
<td>2512</td>
<td>65.83</td>
<td>0.7-1.3</td>
</tr>
<tr>
<td>&lt; 10</td>
<td>20</td>
<td>0.56</td>
<td>9</td>
<td>0.24</td>
<td></td>
</tr>
</tbody>
</table>

Total: 3,571
Dia. Distribution before & after removal

- Before removal:
  - Percentage: 22%

- After removal:
  - Diameter (cm): 0-9.9 - 0, 10.0-19.9 - 0, 20.0-29.9 - 1156, 30.0-39.9 - 776, 40.0-49.9 - 32
  - Percentage: 76%
Having said that, after removal as low thinning

- Majority of the trees stay within 20.0 to 29.9 cm dbh, vol, 200-220 m³/ha; 13-15 m³/ha/y
- Despite having adequate rainfall, without good soils and silvi. regime has no guaranteed of rapid growth
- Not surprising growth of teak in Malaysia is not comparable with other teak plantations within the tropics such as Indonesia or Central America

After first thinning
Rotation cycle

- Sawlogs
- CAIv > MAIv
- CAI stabilized after 15 years
- Proposed 20 years or more for teak in good soils

Expected rotation

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>MAI &amp; CAI (m³/ha/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>2</td>
<td>1.18</td>
</tr>
<tr>
<td>3</td>
<td>1.78</td>
</tr>
<tr>
<td>4</td>
<td>2.33</td>
</tr>
<tr>
<td>5</td>
<td>3.06</td>
</tr>
<tr>
<td>6</td>
<td>3.58</td>
</tr>
<tr>
<td>7</td>
<td>4.14</td>
</tr>
<tr>
<td>8</td>
<td>4.77</td>
</tr>
<tr>
<td>9</td>
<td>5.44</td>
</tr>
<tr>
<td>10</td>
<td>6.22</td>
</tr>
<tr>
<td>11</td>
<td>7.06</td>
</tr>
<tr>
<td>12</td>
<td>7.97</td>
</tr>
<tr>
<td>13</td>
<td>8.91</td>
</tr>
<tr>
<td>14</td>
<td>9.96</td>
</tr>
<tr>
<td>15</td>
<td>10.96</td>
</tr>
</tbody>
</table>

2015
Study sites with extreme site conditions

- Mixed combinations of different soil types with top soils removed
- Compacted soils along expressway
- Annual rainfall is between 1800 and 2050 mm, indicating the middle range of rainfall in humid tropics
- Sites semi-mechanically prepared
- 400 g of chemical fertilizer annually up to 5 years
Observations on extreme sites

- 15-year old, early flowering trees under stress, and short bole height
- Stands contained a high proportion of forked trees which were badly formed (crooked)
- Height growth stagnant

Sites with top soil removed

Sites with top soil removed:

- 2.5-3.0 m
## Growth and yields as comparison

<table>
<thead>
<tr>
<th>AGE</th>
<th>Sites</th>
<th>N</th>
<th>dg (cm)</th>
<th>hg (m)</th>
<th>G (m²/ha)</th>
<th>V (m³/ha)</th>
<th>MAIv (m³/ha/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1 no thinning</td>
<td>832</td>
<td>14.6</td>
<td>13.87</td>
<td>14.00</td>
<td>117.25</td>
<td>7.81</td>
</tr>
<tr>
<td>15</td>
<td>200 stems/ha</td>
<td>204</td>
<td>24.3</td>
<td>18.93</td>
<td>9.49</td>
<td>108.05</td>
<td>7.20</td>
</tr>
<tr>
<td>15</td>
<td>300 stems/ha</td>
<td>323</td>
<td>20.5</td>
<td>17.24</td>
<td>10.7</td>
<td>110.87</td>
<td>7.39</td>
</tr>
<tr>
<td></td>
<td><strong>CL1</strong> High density</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>517</td>
<td></td>
<td>17.2</td>
<td>24.2</td>
<td></td>
<td>144.51</td>
<td>9.63</td>
</tr>
<tr>
<td></td>
<td><strong>CL2</strong> High density</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>597</td>
<td></td>
<td>18.8</td>
<td>30.6</td>
<td></td>
<td>206.06</td>
<td>13.74</td>
</tr>
<tr>
<td></td>
<td><strong>CL1</strong></td>
<td>300</td>
<td>29.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>CL2</strong></td>
<td>300</td>
<td>35.2</td>
<td></td>
<td></td>
<td></td>
<td>6-8*</td>
</tr>
</tbody>
</table>

Source:
* Kijkar S. 1998. (Thailand)
## Soil structure CL1 and CL2

<table>
<thead>
<tr>
<th>Depth (Cm)</th>
<th>Horizon</th>
<th>Granulometric composition (%)</th>
<th>Depth (Cm)</th>
<th>Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Clay</td>
<td>Silt</td>
<td>Fine Sand</td>
</tr>
<tr>
<td>0-6</td>
<td>Ap</td>
<td>53.0</td>
<td>31.7</td>
<td>11.8</td>
</tr>
<tr>
<td>6-43</td>
<td>Bt1</td>
<td>68.8</td>
<td>20.6</td>
<td>8.9</td>
</tr>
<tr>
<td>43-60/80</td>
<td>Bt2</td>
<td>62.8</td>
<td>29.3</td>
<td>6.5</td>
</tr>
<tr>
<td>60/80-79/85</td>
<td>Bt3cn</td>
<td>76.1</td>
<td>12.9</td>
<td>5.5</td>
</tr>
<tr>
<td>79/85-110</td>
<td>Bt4</td>
<td>72.3</td>
<td>19.5</td>
<td>6.2</td>
</tr>
<tr>
<td>110-135</td>
<td>C</td>
<td>73.3</td>
<td>18.4</td>
<td>7.7</td>
</tr>
</tbody>
</table>
Explanations

The better growth performance in CL2 as compared with CL1 could be attributed:

More balance textural composition of the soil, dominated by coarse sand with total sand content in the upper 100 cm ranging from 55 to 80 % and its clay content although was low in the topsoil but increase between 28 and 38 %. High content of coarse sand allowed sufficient aeration within the rooting zone of the soil profile while low clay content and provides good capture of soil moisture. The rooting ability enhanced by the less compact nature and the present of greater volume of coarse sand.

CL1 is composed mainly of fine materials with very high total clay and silt in the upper 100 cm ranging from 85 to 92 %. This could have given rise to a more compact nature of the soil and lesser aeration within the soil profile.
Knowledge generated

1. The results revealed the importance of site selection and soil types in the planting of teak for timber production (loamy vs sandy)

2. Thinning is an important silvicultural treatment to encourage foliage and rapid diameter growth

3. The study showed the actual potentials growth and yield of teak under prescribed management regime

4. The growth and yield of teak may be uncertain if conducted elsewhere, but the results may be used in answering questions related to overall growth rate of the species
Precision site selection realized:

- Early flowering indicating trees are constantly under stress conditions
- Premature uprooting of growing teak
- Should be deep soil or alluvial
- High selection ratio, assist in thinning selection and PCT, less mortality
- $H/D \approx 0.9-1.0$ nothing less
- Sustaining enough PCT at end of rotation period
To conclude:

- Long term observation stands required covering wider site range to convince the investors
- In sawlogs production, clear indication of extended rotation age is required (> 20 years)
- The importance of site quality to match the ecological requirements of teak
- Prescribed silvicultural regimes to meet the objectives
- Government efforts to keep the industry grows
ACKNOWLEDGEMENTS

Director - General FRIM

Sponsorship: Aramijaya Private Limited, Johore Bharu

Working partners & study sites
1. Royal Garden Enterprise, Sabah
2. North-South Expressway, P. Malaysia
I thank you for attending this session, happy to answer questions now or during the break....till we meet again in the 4th World Teak Conference
Diameter distribution (2013)

Diameter (cm) | N1 | N2
--- | --- | ---
0-9.9 | 20 | 9
10.0-19.9 | 2741 | 2512 (76%)
20.0-29.9 | 776 | (22%)
30.0-39.9 | 32 | 126
40.0-49.9 | 2 | 13

Removal
Diameter distribution (after removal)

- 20-29.9: 1156
- 30-39.9: 32
- 40-44.9: 126
- 45-49.9: 2
- >50: 8

CL1

CL2

FRIM
MS ISO 9001 : 2000